Remarks

Drawings

1. Drawings are extended to address every features in claims.
2. 2.1 The conical surface being a diverging curve surface of claim 5 is shown in FIG. 6;

   2.2 The conical surface with 2 conical surfaces of claim 4 is shown in FIG. 5.

   2.3 Plurality of multijet orifices being on the conical surface of claim 7 as well as the various orifice types (semi-circular, arcs, triangles, trapezoids, etc) Are shown in FIG. 7;

   2.4 The variable circular aperture of claim 15 is shown on FIG. 9 (a), the diagrams of flow during low to medium pressure (a) and flow during high pressure of claim 15 are shown in FIG. 9 (a) & (b), respectively.

   2.5 The diagrams for claim 13, where multijet-orifices (6) are distributed on or under the conical surface (C) so that they can be open channels (b) or closed channels (a) are shown in FIG. 8.

   2.6 The diagram of claim 14 is shown in FIG.10, in which a mixed-mode fuel injector has a plurality of multijet-orifices underneath the said conical surface (C), forming a sac-hole (FIG. 10a) or valve-covered-orifice multi-hole type (FIG. 10b) injector through blocking the circular aperture by the needle head at a predefined needle-lift range.

Response to Claim Objections:

3. Claim 11-12 are cancelled. Claim 13 is amended such that it *depends on claim 2 only*. Thus, no new matter is added, multiple dependent is removed.
4. Claim 19 is cancelled.

Response to Claim Rejections – 35 USC § 112

5. First paragraph of 35 U.S.C. 112.
6. Claim 17 is cancelled, so any confusions between claims 1, 2 and 17 would be eliminated. The applicant has two tele-conferences before with the Examiner and Examiner's supervisor. The technical contents for claim 1 & 2 has been clarified

and agreed upon as in interview documents. So the rejections for claim 1 & 2 based on 35 U.S.C. 112 should not be raised again

Applicant made presentation through web-teleconference and disclosed the differences in figure 5 of the Lambert vs. the applicant's invention. The applicant gave specific physical meanings of the micro-variable-circular orifice through a three dimensional assembly drawing. The applicant explained that the injector of Lambert cannot produce two different spray patterns of multiple jets and hollow conical spray. Applicant explained that the first needle lift of Lambert can only generate the multijet (spray) flow, but not the hollow conical spray flow as it did in applicant's invention. The applicant and examiners further discussed the mechanism of lifting the needle valve in applicant's invention while it closes the micro-variable-orifice in order to produce the different spray patterns.

The examiners agreed on with details presented for clam 1, the technical substances were clear and the differences from Lambert's invention were clear.

The examiners made following suggestions which the applicant agreed and were already incorporated in last amendment:

- *Need clearly define the two-type of orifices, i.e., micro-variable-circular-orifice and conventional multijets orifices or passages, including the locations and compositions;*
- *Need clearly define the two distinguished spray patterns (multijets and hollow conical spray) produced by the above two type orifices;*
- *Need define the scenarios when flow is passing along one of the above orifices and both of the orifices;*
- *Need add figures to illustrate nozzle body along, needle along, and assembly to more clearly illustrate the mirco-variable-circular orifice;*
- *Statements in specification can be revised under the condition of without adding new matters to make it more clear;*

7. *Second paragraph of 35 U.S.C.112.*
8. *The inventions were clearly pointed out in claim 1, 2, 13, 14, 15, 16 and other claims. The Conical Surface (C) is clearly marked on FIG 2. The definition of this Conical Surface applys to all claims. There are two major design options for the multijet-orifices – that 'ON the conical surface' (C), as stated in claim 7, and is shown in FIG. 7 (a) & (b); that 'underneath the conical surface' (C), as stated in claim 13, 14, and is shown in FIG 8 (a), FIG. 9 (a) & (b), FIG. 10 (a) & (b). The*

Examiner's interpretation of the conical surface being the needle seating surface (2) is not correct. The seal surface (2) is clearly marked in FIG. 2 and stated in claim 1, which is obviously different from the Conical Surface (C). The specific combination of needle lift magnitude and spray patterns, as stated in claim 1, 2, 15, 16, has not been disclosed in any previous art. They are the key inventions for this application.

9. *Please refer FIG. 6. Such a curved surface (C) feature is not presented in previous arts. Thus Claim 5 is patentable.*

Response to Cliam Rejections – 35 USC §102

10. *35 USC §102 quotation as in the Office action document.*

11. *Claims 1-4, 5, 8, 14-16, 18 stands, they produce different spray patterns during the needle lift process. More specifically, in Date's design:*

- *Small needle lift – multiject spray;*
- *Middle level needle lift – hollow conical – multijet spray;*
- *Large needle lift – hollow conical spray;*

In contrast, in Hou's 10/597,000 design:

- *Small needle lift – hollow conical spray;*
- *Middle level needle lift – hollow conical – multijet spray;*
- *Large needle lift - multijet spray;*

Also, Gate did not give any other designs such as multijet orifice ON the conical surface (C), Date did not give flow guide conical surface (C), Gate did not give a simple and smooth needle head curvature design as Hou did, as shown in FIG. 2.

Hou's design significantly improves the fuel injection adaptability and performance. In contrast, Date's design produces a spray pattern that is exactly what we want avoid in practical applications. Also, Gate's design has a section of guide (33) which is a significant concern of reliability for operation, since matching two surfaces(33 & 30 in Gate's FIG. 3) with small clearance in high speed needle open-closing operation is a very challenging task. In Summary, Hou's design significantly improves the reliability and capability for practical applications. Further, in Hou's design, the needle surfaces close to needle head are much simple and smooth curvatures which benefits guiding the fuel flow.

12. *What Simmons disclosed in U. S. Patent #3,042,317 is a mechanical puppet valve, which was manually activated by screws, it's a far different concept than Hou's invention disclosed here. Simmons's invention was related to an 'outward opening' valve, the sealing surface (15 in #3,042,317's FIG 1) is outside the nozzle body, which is completely different than Hou's invention, which is an 'inward opening' valve, and the sealing surface (2 in Hou's FIG 2) is inside the nozzle body.*

Response to Claim Rejections – 35 USC 103

13. *Since Hou's invention produce different spray patterns in different sequence than Date's invention, Hou's invention bears significant advantages for advanced combustion, as already discussed in above. It is not an obvious matter to change spray pattern varying sequence to fit for needs of advanced combustion. Thus, the rejections of claims 6,7,9-10 under 35 U.S.C. 103 (a) does not apply.*
14. *Claim 20 is canceled.*

The applicant has searched the related patents listed by patent examiner, and fund none of the prior art can give variable spray patterns including a hollow conical spray and multijet spray, in the given sequence, through a single injector with a single needle valve as defined in the patent application 10/597,000. The applicant believes that the said injector is unique and bears inventions and merits not provided by prior arts, it's applicable for industrial applications.

Respectfully submitted,

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Please recognize our Customer No. 45462